Section 1: Planning Before You Begin

Photo Courtesy of Virginia Save Our Streams

Chapter 1

Planning Your Monitoring Program

Planning Your Monitoring Program

Careful planning of your water quality monitoring program prior to recruiting volunteers and purchasing equipment is important because it can save considerable time and money. The Virginia Citizen Water Quality Monitoring Program provides technical assistance and training services to citizen monitoring organizations. When planning your program, you may want to consider creating a committee of others interested in your program, such as data users, local college faculty, potential volunteers, local government staff, etc.

> You can purchase a test kit and monitor water quality in your backyard for your own information. If you want your data to be useful to others, however, careful planning is important.

Appendix 10 contains worksheets that will be helpful in developing your monitoring program. Completion of the worksheets will help you focus your efforts and assist you in developing a program that collects useful data to meet the goals of your program. Appendix 11 provides additional technical information about planning a water quality monitoring program.

> Joining an existing water quality monitoring program or working cooperatively with an established program is the easiest route for collecting water quality information as many of the decisions discussed in this chapter have already been made.

Your monitoring plan may change as your program evolves. For that reason, it is important to periodically update your monitoring plan. For example, program coordinators might find that a method is not producing high enough data quality, data collection is too labor-intensive or expensive, or additional parameters need to be monitored.

Step 1: What waterbody(ies) do you want to monitor and what is known about your watershed?

The first step is to determine what waterbody(ies) you want to monitor and if any monitoring data has been collected there previously. The Virginia Water Monitoring Council (VWMC) is comprised of organizations and agencies involved with water quality monitoring. Since the mission of the VWMC is to promote and facilitate coordination of water monitoring programs throughout Virginia, the VWMC has developed an online database that allows users to determine whether water quality data is or has been collected in a specific watershed. While this database is the most comprehensive source of water quality monitoring

Who is Monitoring in Your Watershed?

- Virginia Department of Environmental Quality Water Quality Monitoring Database http://www.deq.state.va.us/water/monitoring.html
- Virginia Water Monitoring Council http://www.vwrrc.vt.edu/vwmc/Survey.asp

information, it may not include every source of data about your watershed. The Virginia Department of Environmental Quality's (DEQ) online water quality monitoring database allows you to view water quality monitoring data (both current and historical) collected by the agency. Local governments may also have data or other documents that describe local water quality issues.

Collecting information on the issues affecting your watershed is important in planning an effective monitoring program. Knowing the issues and what is already being monitored may help you to decide what to monitor and keep you from duplicating efforts. For example, a local college may be monitoring the same sites that you were planning to monitor. It is not practical for both entities to spend money and time collecting the same information at the same sites.

Step 2: Why are you monitoring?

Once you have determined what is known about your watershed, you should determine the overall goals for your monitoring program. This is the most important step in planning your program because other questions about the monitoring program (Steps 3-7) depend upon this initial step.

Establishing Goals for Monitoring is Critical to Determine:

- How your data can be used and how good it needs to be
- Where you will monitor
- What parameters or conditions you will measure
- What methods you will use to monitor
- When you will monitor

After you have researched the issues of the watershed, you should identify specific questions you want to answer and the information needed to address the issues. Can you collect volunteer data that can help fill in any data gaps?

Determining why you want to collect data is important in collecting useful information without wasting time and money. Common goals of citizen water quality monitoring programs include:

- Educating the local community about water quality issues to encourage protection of water quality
- Establishing baseline data where no other data exists
- Supplementing water quality data collected by agencies
- Documenting water quality changes over time (trends in water quality)
- Identifying potential water quality problems
- Providing a scientific basis for making decisions on watershed management
- Providing information to evaluate the effectiveness of best management practices
- Determining the impact of land use activity (urban, industrial, agricultural, etc.)

Step 3: How will your monitoring data be used and what level of data quality do your data users need?

Understanding how your data potentially will be used is essential to the program development. Partnering with potential data users during the planning process can improve the likelihood they will use your data. Some users, such as state agencies, will have more stringent requirements on the level of data quality needed and will require higher levels of quality assurance and quality control activities (activities used to assure data quality) than other data users. The range of uses of volunteer data uses is limited only by the imagination (Appendix 2).

Potential Data Users of Volunteer Data

- Environmental organizations
- State environmental agencies
- Local health departments
- Environmental consultants
- Universities/schools
- Local park staff
- Local planning and zoning agencies
- Soil and Water Conservation Districts
- U.S. Geological Survey
- U.S. Environmental Protection Agency
- U.S. Fish and Wildlife Service

Step 4: Where will you monitor?

Selecting representative sites is an important element in designing your monitoring program. Site locations will depend on the goal of the program. When selecting sites, you should consider the following questions:

- Is there a real need for data at the proposed sites?
- Do the proposed sites duplicate existing monitoring efforts by other organizations or agencies?
- Are the proposed sites in the main flow of the stream and representative of the stream (for smaller streams this is typically mid-channel and just below the water surface)? Representative also means that samples are not collected near a discharge pipe where the discharge mixes with the water in the stream.
- Are the proposed sites safe and easily accessible?
- Are the proposed sites on public property or can you obtain landowner permission?
- Is a proposed site above or below the confluence of two streams? If the site is below the confluence, the watersheds of both streams affect the water quality at the site.
- Can a representative water sample be collected during all tidal stages?

Selecting Sites

To make your program most effective, you may wish to discuss your potential site locations with the DEQ Citizen Monitoring Coordinator, who can provide assistance on site selection. It may be beneficial to discuss potential sites with intended local data users, including your local soil and water conservation district and your local government environmental staff.

Identifying Sites

Once you select the monitoring sites, you must be able to identify each site location. Your data is not useful without the exact monitoring location. Determine latitude and longitude using a GPS unit in the field or pinpointing the site on a U. S. Geological Survey (USGS) 7.5 minute series topographic map (1:24,000 scale).

Obtaining USGS Topographic Maps

- Use the maps on http://www.topozone.com at no cost (see Appendix 12 for instructions for using Topozone).
- The USGS Earth Science Information Center (ESIC) provides a catalog of available maps and a brochure on how to use topographic maps. Contact the main ESIC office at 888-ASK-USGS or at http://ask.usgs.gov.
- Commercial distributors include sporting goods stores and engineering/architectural suppliers

In addition to latitude and longitude, a brief description of the site location (i.e. north side of Rt. 0 bridge crossing Deer Creek) is useful. A narrative description provides a way for someone to quickly identify the site location without plotting the latitude and longitude.

Assigning Site Numbers

You should develop a systematic approach to assigning site identification numbers. Identifying each site by an assigned unique number provides greater consistency than using a site name, which may be modified easily by newcomers to your program.

Sampling Depth

In addition to geographic location, you need to determine the depth you plan to sample in the water column. For most volunteer programs, just below the surface will be sufficient for most parameters. DEQ surface water samples are typically 0.3 meters (1 foot). If you are planning to monitor a lake or deep estuarine waters, this is a critical question, particularly for dissolved oxygen monitoring. Dissolved oxygen in lakes and the Chesapeake Bay can vary greatly with depth (this vertical stratification is discussed further in Chapter 4). Sampling at greater depths (greater than 1 foot or 0.3 meters) may require special water sampling devices (see Chapter 4).

Step 5: What parameters or conditions will you measure?

Our waterways are complicated systems. Determining what to monitor will depend on the goals of your program, the intended use of the data, the needs of the data users, and the resources of your volunteer monitoring program. If, for example, your goal is to provide baseline data that will be useful to state water quality agencies, you should consult those agencies to determine which parameters have state water quality standards and which they consider of greatest value.

DEQ is most concerned with parameters for which Virginia has water quality standards (please refer to the Introduction of this manual). Costs of test kits or meters, available laboratory facilities, assistance from state or university advisors and/or laboratories, and the abilities and desires of volunteers will also have an impact on the choice of parameters to be monitored. Table 2-1 lists some water quality parameters that are commonly monitored by volunteer monitoring programs in Virginia. More detailed information can be found in Chapters 4-17.

Table 2-1. Common Water Quality Parameters

Parameter	**Virginia Water Quality Standard**	**Importance**
Dissolved Oxygen	Yes	Essential for aquatic organisms.
pH	Yes	Affects chemical and biological processes; organisms can only survive in specific range.
Nitrogen	Standard for nitrate in public drinking water supplies; others to be developed.	Essential for plant growth; necessary for metabolism and growth of aquatic organisms.
Phosphorus	Screening value for total phosphorus; standard to be developed.	Essential for plant growth; necessary for metabolism and growth of aquatic organisms.
Benthic Macroinvertebrates	Narrative standard	Good indicators of water quality.
Bacteria	Yes	Indicator of fecal contamination; can cause illness.
Chlorophyll *a*	Screening value for Chlorophyll *a*	Estimates the abundance of algae.
Submerged Aquatic Vegetation (SAV)	No	Food and habitat for aquatic organisms.
Temperature	Yes	Affects chemical and biological processes.
Turbidity/Transparency or Total Solids	No	Indicators of runoff effects; affect sunlight reaching SAV.
Salinity	No	Affect the distribution of plants and animals in estuarine environments.
Conductivity	No	Useful measure of general water quality. Significant changes may indicate a discharge or another source of pollution.

Step 6: What methods will you use to monitor?

For most parameters, there are a variety of monitoring methods available with varying complexity and levels of data quality. You should select methods based upon cost and the quality of data necessary to meet the goals of the program and the intended data use. For example, data intended for water quality assessment use by DEQ must be collected using DEQ-approved methods and requires a higher level of data quality than data used to screen for potential problems (Appendix 9). You can, for many parameters, begin monitoring using less sophisticated equipment and upgrade your methods as resources allow. Partnering with colleges and universities is beneficial since they generally have technical knowledge and often have equipment available (please refer to the Winter 2003 edition of *The Volunteer Monitor* newsletter available at http://www.epa.gov/owow/monitoring/volunteer/winter2003/volmon15.pdf).

Meters may be used to measure many water quality parameters such as temperature, dissolved oxygen, pH, and conductivity/salinity. Although meters are quick to use in the field, they are more expensive than test kits and require calibration and maintenance to ensure accuracy. Sophisticated equipment will not provide better data if it is not properly used. Field test kits for the same parameters may be less expensive but may be unacceptable to some data users. Please refer to Chapters 4-17 for discussions of appropriate methods for commonly measured parameters.

When choosing a method, you should consider the detection limit (the smallest concentration of a parameter that can be detected) and the range. When selecting a test kit or other method, it is helpful to first determine the average value for the parameter in your stream so that you can select an appropriate method. For example, a test kit whose detection limit is 0.2 mg/l for total phosphorus will not be very useful if the typical total phosphorus concentrations are 0.04 mg/l. The importance of the detection limit depends heavily on the intended use of the data. While results from the total phosphorus kit mentioned above might not have much use from an agency perspective, it can detect when total phosphorus levels are elevated.

Step 7: When will you monitor?

In deciding when to monitor, you should consider several time scales: time of year, monitoring frequency, time of day, and sample holding time.

Time of Year

Aquatic ecosystems change seasonally and the data usually reflects these changes. During wet weather, more runoff carrying bacteria, nutrients, and pollutants enter waterways. Therefore, higher levels of these parameters generally are found during rainy seasons. Seasonal temperature changes greatly influence dissolved oxygen levels as colder water can hold more dissolved oxygen than warmer water. Due to seasonal variability, water quality monitoring events should be distributed throughout the year.

Monitoring Frequency

Ultimately, sampling frequency depends on the goals of the program, financial resources, and volunteer resources. For the purpose of DEQ's water quality assessment, sampling events should be conducted in such a manner that each sampling event represents an "independent" measure of water quality. Monitoring events are not considered independent if they are not sufficiently separated in time. Although the interval between sampling events that is necessary to insure independence of measurements is parameter-specific, a longer interval ensures the independence of the observations. Water quality monitoring events should be distributed evenly throughout the year on a certain interval (such as weekly, biweekly, monthly, bimonthly, or quarterly). When determining the sampling interval, you should keep in mind that one or two sampling events are generally not very useful in determining the water quality at a station. Larger data sets can be used to discriminate among rare, sporadic, frequently recurring, or continuous water quality issues.

Sampling several times during the year is sufficient for benthic macroinvertebrates since they indicate conditions over a long period of time. The VA Save Our Streams Program (VA SOS), for example, trains volunteers to sample macroinvertebrates once each season. Sampling of bacteria in a popular swimming area may be performed more frequently during the summer if the goal of the program is to determine if the water quality is safe for swimming.

Time of Day

Since some parameters (dissolved oxygen, pH, water temperature) fluctuate depending upon the time of day they are measured, it may be helpful to select a consistent sampling time for a site. Volunteers cannot be expected to always sample at the same time of day, but some consistency can help reduce the daily variability in the data. More data collected at a site over time will better identify some of this daily variability.

Temperature, dissolved oxygen, and pH can fluctuate naturally as the sun rises and aquatic plants undergo photosynthesis. Dissolved oxygen levels, for example, are generally lowest at sunrise and highest in the afternoon as aquatic plants consume oxygen during the night and release oxygen as a byproduct of photosynthesis during the day.

If you are monitoring tidal waters, tidal action affects the representative natural conditions of the water body. Most volunteer programs do not monitor based upon tidal stage because it is not reasonable for volunteers to adapt to the continuous time changes of tidal stages. If possible, it is preferable to collect samples on the ebb or slack tide.

Holding Time of Samples

The maximum time that samples can be held before testing (holding time) should also be considered. Delivering samples to a lab on a Friday afternoon is not reasonable if the lab is closed on weekends and the samples have a short holding time.

Step 8: How will you manage your data and present your monitoring results?

You should have a clear plan for handling the data collected. Someone must check field and lab data sheets while screening for outliers (results that differ significantly from past or expected results), enter the data into an electronic format, and check for data entry errors. Where will the data sheets be stored? You may need to develop or adapt an electronic database or spreadsheet to store and manipulate the data so that it will be more readily available for data users. DEQ has developed a format for submitting data to the agency for the 305(b) Water Quality Assessment Report that you may want to adapt for your own use (Appendix 4). The U. S. Environmental Protection Agency (EPA) maintains a national database for water quality, biological, and physical data called STORET. STORET permits national data analyses and allows the sharing of data among organizations. Specific quality control measures are required for any data entered into the database. For more information, please see http://www.epa.gov/storet/.

In creating a database, having a plan for analyzing and communicating the data to the public, to data users, and to the volunteers is useful. Raw data may have limited meaning to the public without some summarization and interpretation of the results. The volunteers will more than likely want to know "what the data means."

Step 9: How will the program ensure that data are credible?

Making decisions and answering the questions addressed in Steps 1-8 are the first steps to ensuring that the data collected by your program is credible. The level of data quality needed is dependent upon the goals of your program and the intended uses of the data. If the goal of your program is education, then data credibility may not be a high priority. If your program is designed to collect data that can be used in making management decisions or to assess water quality, data credibility is very important.

Potential data users may be skeptical of volunteer data and have doubts about the ability of the program to collect accurate results. A written plan, known as a Quality Assurance Project Plan (QAPP), is key to overcoming this skepticism. The QAPP documents all aspects of your program, including the training and retraining of volunteers, the methods used to collect the data, data management, data reporting, equipment checks and project goals. Without such documentation, the data may not be used with confidence. The QAPP is also important for educating future volunteers and data users about every aspect of the program.

Please see Chapter 2 for a detailed description of developing a QAPP.

Chapter 2

Developing a Quality Assurance Project Plan

What is a Quality Assurance Project Plan (QAPP)?

The quality assurance project plan is a written document that describes all aspects of your program and includes the detailed quality assurance and quality control activities that will be used to assure data quality. The QAPP describes the organization of the program and includes the standard operating procedures (SOPs) for sample collection in the field and lab analysis. The monitoring plan you developed in Chapter 1 is the foundation for the QAPP. If you have carefully completed the worksheets in Appendix 10, you already have most of the information needed for your QAPP!

What Does a QAPP Include?

- Who does what?
- Project goals
- How good does the data need to be to meet goals?
- Training of volunteers
- Documentation (field sheets, lab sheets)
- Sample Design: who, what, when, where, how
- Methods used (field SOPs)
- Sample handling and analysis (lab SOPs)
- QC requirements
- Equipment calibration, checks, and maintenance
- Data management, reporting, and review

Quality assurance (QA) and quality control (QC) are those activities you undertake to demonstrate the accuracy (how close to the true result you are) and precision (how reproducible the results are) of your monitoring. QA generally refers to a broad plan for maintaining quality in all aspects of a program, including quality control measures, sample collection, sample analysis, data management, documentation, etc. QC consists of the steps, including measurements, calibrations, etc., you will take to assure the quality of specific sampling and analytical procedures. The Virginia Water Monitoring Council has developed a handout explaining basic QA/QC concepts (Appendix 13).

Why is a Quality Assurance Project Plan Important?

If the goal of your volunteer monitoring program is to collect data that can be used for management decisions, your data users may require a QAPP or at a minimum documentation of your methods. The QAPP provides the documentation that assures the quality of the data to your data users. The burden of proving the data quality is on your organization.

Although the development of a QAPP may appear to be a difficult process, it will be well worth the effort to see your data used in a meaningful way. Seeing the program's data used may provide additional motivation for retaining and recruiting volunteers who want their efforts to be worthwhile. A written QAPP is also important for educating future volunteers, project managers, and data users about the program and how the program is organized.

For the Department of Environmental Quality (DEQ) to use volunteer data for 305 (b) water quality assessment, the data must be collected under a DEQ-approved QAPP using QA/QC measures acceptable to DEQ. The U. S. Environmental Protection Agency (EPA) requires that any monitoring program sponsored by EPA through grants, contracts, or other formal agreements carry out a quality assurance/quality control program and develop a quality assurance project plan.

How Do You Develop a Quality Assurance Project Plan?

Developing a QAPP is a dynamic process that should involve consulting the data users for their requirements. Seeking advice from other organizations using similar methods also can be helpful. The DEQ Citizen Monitoring Coordinator is available to provide assistance with QAPP development. Any program seeking DEQ approval of a QAPP should submit the plan to the DEQ Citizen Monitoring Coordinator.

DEQ recommends that all citizen water quality monitoring QAPPs follow the format outlined in *The Volunteer Monitor's Guide to Quality Assurance Project Plans* developed by EPA. This guide is available at http://www.epa.gov/owow/monitoring/volunteer/qappcovr.htm. Appendix 14 is a QAPP template from the EPA guide that you can use for developing your QAPP.

Chapter 3

Before You Begin

Preparation for Monitoring

Volunteers should check their equipment, test kits, and reagents (chemicals) to ensure that they are in proper condition prior to sampling. Data sheets and labels for lab samples can be prepared at home prior to monitoring to save time and minimize errors in the field.

Reused sample containers and glassware should be cleaned and rinsed after each sampling event. All reagents should be stored tightly capped away from heat, sunlight, and extreme cold. All reagents should be stored out of the reach of children and pets.

Signs of Degraded Reagents

- Color has changed
- Reagent has floating particles or solids forming
- Crust has formed around lid
- Past expiration date (Appendix 15 gives instructions on determining the expiration date of some commonly used test kit reagents)

Safety

Safety is the most important element of any volunteer monitoring program**. No data is more important than safety! Safety always comes before data collection.** If a site appears severely polluted or there is an urgent problem (such as fish kill, leaking drum, or oil spill), volunteers should **not** sample and immediately report the pollution event to the Virginia Department of Environmental Quality (DEQ) for investigation.

Reporting an Urgent Pollution Event

- During normal work hours, call the appropriate DEQ Regional Office. A map of DEQ Regional Offices and phone numbers to report pollution incidents can be found at http://www.deq.state.va.us/prep/contacts.html.
- On nights, holidays, and weekends call the Department of Emergency Management's (DEM) 24-hour reporting number.
  In-state calls: 800-468-8892.
  Out-of-state calls: 804-674-2400
- Assemble the following information about the pollution event (if known): location of the pollution event (so that staff can investigate), when was the pollution event observed (report as soon as possible), what is the observed problem and who is causing the problem.

Training for all volunteers should include a safety component. All volunteer monitors are encouraged to sample in teams or with partners and to inform someone where they are going and when they plan to return. All monitoring stations should be safe for volunteers to access and perform their sampling. All volunteers should be instructed to take additional safety precautions in high water conditions. Additional safety rules for volunteer monitors can be found in the box on the next page.

Safety Rules for Volunteer Monitors

- Watch weather reports prior to going into the field.
- Carry first aid kit and water.
- Dress properly for the weather. Don't forget to wear blaze orange during hunting season! The Department of Conservation and Recreation (DCR) has a limited number of orange vests available through the Adopt-A-Stream Program at adoptastream@dcr.state.va.us.
- Sample in teams or with partners.
- Inform someone where you are going and when you plan to return.
- All monitoring stations should be safe for volunteers to access and perform their sampling.
- Inform sampling team members of relevant health information in case of emergency.
- If you do not feel comfortable with the monitoring site or your surroundings, leave the site.
- If the site appears severely polluted, report immediately.
- If you drive to site, park in a safe location.
- Do not cross private property without permission.
- Watch out for poisonous plants and wildlife. Dress appropriately for protection against ticks.
- Be careful on bridges, stream banks, boats, docks, and when wading. If you monitor from a boat, abide by all boating regulations (see the Virginia Department of Game and Inland Fisheries website at http://www.dgif.state.va.us/boating).
- Do not wade in fast moving or high water.
- Use antibacterial soap after monitoring and do not eat until you have washed your hands.
- Avoid contact between chemicals and skin, eyes, or mouth. Wearing gloves is recommended.
- Properly store all chemicals away from children and pets, while avoiding extreme temperature fluctuations and direct sunlight.
- Properly clean up and dispose of any spills of chemicals.
- Properly dispose of all wastes from test kits.

Collecting Water Samples

Sections 2-4 of this manual discuss different types of sampling methods for various parameters in more detail. There are some general rules of thumb that you can apply for collecting water samples. Water samples should be collected in the main flow representative of the stream you are monitoring (for small streams, this is usually mid-channel). Please see the box on page 3-4 for more information.

Samples being transported to a lab should be properly labeled. It is recommended that lab sample labels include the name of the collector, site number, date, and time in case the lab has any questions about the sample. Samples being transported should be properly preserved (usually in a cooler with ice – blue ice packs are not recommended).

Using a Meter

- When using a meter to measure stream conditions, it is recommended that you place the meter directly in the stream or lower it from a bridge (please see the box on page 3-4 for more information). An alternate method is to collect the water sample in a bucket and use the meter to immediately take measurements in the bucket.
- Always be careful that the probes are protected from impact and are placed in an area representative of the stream.
- Meter probes should be lowered to about 0.3 meters (1 foot) below the surface of the water.

Samples Collected Directly from Stream with Sample Containers

- If possible, collecting water samples directly from the stream is preferable to using a bucket as it reduces the possibility of contamination and carryover from previous sampling, especially for bacterial sampling. If wading is not possible for collecting bacterial samples, consider using an extension pole for your bacteria sample bottle.
- When wading, approach sampling location from downstream.
- While facing upstream, thoroughly rinse sample bottles with stream water (do **not** rinse sample containers used for bacterial samples). If rinsing containers with sample water, discard rinse water downstream of sample site or on the stream bank.
- Collect samples while facing upstream and avoid disturbing sediment.

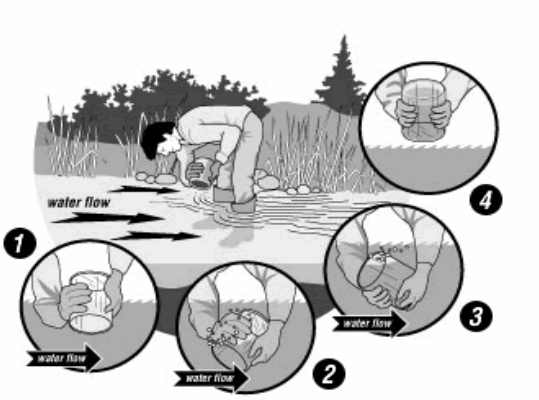

Figure 3-1. Collecting a water sample *(from Volunteer Estuary Monitoring: A Methods Manual, Second Edition).*

Samples Collected Directly from Stream with a Bucket

- Gently toss or lower bucket into an area representative of the stream (please see box on page 3-4 for more information on collecting samples from a bridge or by wading). If you are collecting sample water for dissolved oxygen analysis, be especially gentle. Splashing the water in your bucket can aerate your sample and alter your results.

- Rinse the bucket thoroughly with sample water before collecting sample water. Do **not** rinse the bucket if you are collecting water for bacterial sampling. Discard rinse water downstream of sample site or on the stream bank.

Collecting Water Samples

- Samples should be collected in the main flow representative of the stream you are monitoring (for small streams, this is usually mid-channel) just below the water surface, about 0.3 meters (1 foot) deep.
- Samples should not be collected in stagnant water or next to the stream bank.
- Sample collection is not recommended in the immediate mixing zone of a discharge. Only samples representative of the stream (once effluent is well mixed with the stream flow) can be used by DEQ for water quality assessments.
- If you collect samples by wading, you should be careful and always approach the sampling location from downstream trying to disturb bottom sediment as little as possible. You should always face upstream to collect your samples or take measurements.
- If samples are collected from a bridge, you should collect from the upstream side of the bridge if there are no cables present. If cables are present, use the downstream side of the bridge.